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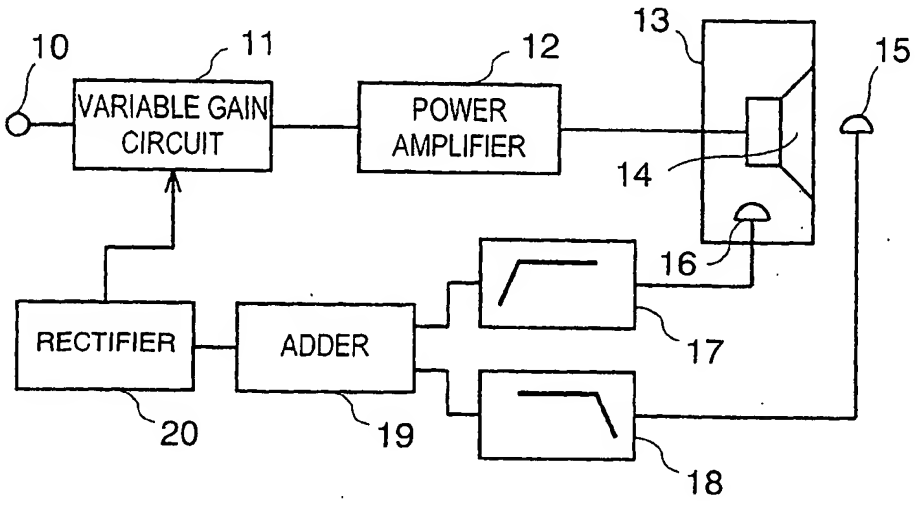
(54) Audio reproducing apparatus

(57) An audio reproducing apparatus is utilized in noisy environment of which noise level greatly varies. The apparatus includes first and second microphones placed respectively inside and outside a speaker box. Outputs of respective microphones are filtered, and then added with each other so that signals proportional to outside noise can be extracted. A gain of variable gain circuit can be changed with these extracted signals, whereby sound easy to follow even in noisy circumstances can be reproduced.

FIG. 1



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Description

Field of the Invention

[0001] The present invention relates to an audio reproducing apparatus that can excellently reproduce signals even at a noisy place such as a factory and transportation means including cars and trains.

Background of the Invention

[0002] There are a lot of opportunities to reproduce audio signals at a noisy place, where a noise level is high and varies, such as a factory, transportation means including cars and trains.

[0003] Fig. 6 is a block diagram illustrating a conventional audio reproducing apparatus that is utilized in noisy environment. In Fig. 6, an audio signal received at input terminal 1 travels through variable gain circuit 2 and is amplified by power amplifier 3. An output signal tapped off from amplifier 3 is fed into speaker unit 5 disposed in speaker box 4, thereby reproducing the signal into audio form.

[0004] Microphone 6 disposed around speaker unit 5 collects the sum of the signals which speaker unit 5 radiates and noises around speaker box 4. An output signal supplied from microphone 6 together with the output signal from amplifier 3 are fed into subtractor 7.

[0005] Subtactor 7 subtracts an input signal component from the sum of the signal radiated from speaker unit 5 and the noises around speaker box 4 so that an output signal proportional to the surrounding noise is extracted. The output signal supplied from subtractor 7 runs through low pass filter 8 where a frequency band of the signal is limited, and then runs through rectifier 9 where the output signal is converted into direct current (dc), then is fed into variable gain circuit 2.

[0006] Because variable gain circuit 2 is automatically controlled its amplifying rate by the output signal supplied from subtractor 7, speaker unit 5 can radiate signals free from being cancelled by the surrounding noise, i.e. free from being masked. As already discussed, the output signal supplied from subtractor 7 varies proportionally to the surrounding noise, which contributes to this automatic controlling.

[0007] However, in the conventional audio reproducing apparatus utilized in the noisy environment, differences exist between the audio signals supplied from speaker unit 5 and the output signals supplied from amplifier 3 so that subtracter 7 cannot completely remove the radiated signal from speaker unit 5. Therefore, it is difficult to extract only the noises around speaker box 4, and a user is thus obliged to control variable gain circuit 2 within a narrowly limited frequency band. The conventional audio reproducing apparatus utilized in noisy environment thus has not been provided with a sufficient masking correction.

Summary of the Invention

[0008] The present invention addresses the problem discussed above and aims to provide an audio reproducing apparatus that can provide a more faithful masking correction by (a) removing sufficiently the radiated signals supplied from speaker unit 5 and (b) varying the gain responding to the surrounding noise.

[0009] The audio reproducing apparatus of the present invention comprises the following element:

(a) a power amplifier;
(b) a speaker box including a speaker unit which reproduces output signals from the power amplifier;
(c) a first microphone disposed outside the speaker box;
(d) a second microphone disposed inside the speaker box;
(e) a low pass filter (LPF) coupled to the first microphone;
(f) a high pass filter (HPF) coupled to the second microphone;
(g) an adder for adding an output from the LPF and an output from the HPF;
(h) an ac/dc converter for converting an ac output signal to a dc output signal; and
(i) a variable gain circuit disposed at an input side of the power amplifier, and an output signal of the circuit being varied responsive to a level of the dc output signal supplied from the ac/dc converter.

[0010] A gain of the variable gain circuit is changed by the output signal of the adder so that the better masking correction responsive more faithfully to the surrounding noise can be achieved.

Brief Description of the Drawings

[0011] Fig. 1 is a block diagram illustrating an audio reproducing apparatus of the present invention.

[0012] Fig. 2 shows output characteristics of a first microphone employed in the audio reproducing apparatus of the present invention.

[0013] Fig. 3 shows output characteristics of a second microphone employed in the audio reproducing apparatus of the present invention.

[0014] Fig. 4 shows output characteristics of a low pass filter employed in the audio reproducing apparatus of the present invention.

[0015] Fig. 5 shows output characteristics of a high pass filter employed in the audio reproducing apparatus of the present invention.

[0016] Fig. 6 is a block diagram of a conventional audio reproducing apparatus.

Detailed Description of the Preferred Embodiment

[0017] A preferred embodiment of the present inven-

tion is described hereinafter with reference to the accompanying drawings.

[0018] Fig. 1 is a block diagram of an audio reproducing apparatus of the present invention. In Fig. 1, a signal received at input terminal 10 is fed into variable gain circuit 11, which is controlled by a signal responsive to surrounding noise. An output signal supplied from variable gain circuit 11 is fed into power amplifier 12, which outputs a signal to speaker unit 14 disposed in speaker box 13.

[0019] First microphone 15 disposed in front of speaker unit 14 collects sum of audio signals radiated from speaker unit 14 and the surrounding noise. Further, second microphone 16 is disposed behind speaker unit 14 in speaker box 13. Second microphone 16 dedicates itself to collect the audio signals radiated from speaker unit 14.

[0020] Fig. 2 shows transfer frequency of the output signal supplied from first microphone 15 with regard to the output signal from power amplifier 12, and phase characteristics of the frequency. As Fig. 2 tells, a level of the signal radiated from speaker unit 14 shows a characteristic similar to that of a quadratic high pass filter (HPF). Fig. 3 shows transfer frequency of the output signal supplied from second microphone 16 disposed in speaker box 13 with regard to the output signal from power amplifier 12, and phase characteristics of the frequency. As Fig. 3 tells a level of the signal radiated from speaker unit 14 shows a characteristic similar to that of a quadratic low pass filter (LPF).

[0021] As such, each output signal supplied from first and second microphones 15 and 16 is similar to respective signals passed through HPF and LPF which have the minimum resonant frequency (f_0) of the speaker unit in common.

[0022] Then, prepare quadratic HPF 17 and quadratic LPF 18 of which cut-off frequencies are adjusted to the minimum resonant frequency (f_0) of speaker unit 14. Couple an output of first microphone 15 with quadratic LPF 18, and couple an output of second microphone 16 with quadratic HPF 17.

[0023] As a result, an output frequency and a phase characteristic of the output signal of first microphone 15 passed through quadratic LPF 18 have almost the same band pass characteristics as those of second microphone 16 passed through quadratic HPF 17. These situations are illustrated in Fig. 4 and Fig. 5.

[0024] Respective first and second microphones 15 and 16 are disposed at front and rear with regard to speaker unit 14. The signal phases supplied from both the microphones form reverse phases with each other.

[0025] When adder 19 adds an output signal from filter 18 to an output signal from filter 17, the signal component radiated from speaker unit 14 is removed so that only the surrounding noise collected by first microphone 15 can be extracted.

[0026] An ac signal supplied from adder 19 and proportional to the surrounding noise is converted to a dc signal by rectifier 20, and then is applied to variable gain circuit 11. Then an amplifying rate of variable gain circuit 11 varies, which realizes an automatic gain control responsive to the noise around the speaker. As a result, a better masking correction faithful to the surrounding noise can be achieved.

[0027] In the embodiment discussed above, first and second microphones 15 and 16 are disposed outside and inside the speaker box 13, and reproduction signals by the speaker form reverse phases viewed from the speaker unit 14. However, the reproduction signals by the speaker viewed from speaker unit 14 do not necessarily form a precise reverse phase. In this case, electrically-reverse-phase-relation can be established by a circuit structure of the quadratic LPF 18 and HPF 17, thereby producing the same effect as this embodiment.

[0028] As described above, according to the present invention, two microphones are disposed inside and outside the speaker box respectively, and respective outputs thereof are filtered so that the signal component supplied from the speaker unit can be removed. Only the outside noise can be thus collected, and the output of the speaker can be varied responsive to the surrounding noise.

[0029] The embodiment discussed above described the apparatus which automatically controls the gain of the variable gain circuit; however, the gain is not always automatically controlled. For example,the surrounding noise level is displayed so that the gain can be manually controlled.

Claims

1. An audio reproducing apparatus comprising:

   (a) a power amplifier;
   (b) a speaker box including a speaker unit which reproduces output signals from said power amplifier;
   (c) a first microphone disposed outside said speaker box;
   (d) a second microphone disposed inside said speaker box;
   (e) a low pass filter coupled to said first microphone;
   (f) a high pass filter coupled to said second microphone;
   (g) an adder for adding an output from said low pass filter and an output from said second low pass filter;
   (h) an ac/dc converter for converting an ac output signal to a dc output signal; and
   (i) a variable gain circuit disposed at an input side of said power amplifier, and an output signal of the circuit being varied responsive to a level of the dc output signal supplied from said ac/dc converter.

2. The audio reproducing apparatus as defined in Claim 1 wherein said first microphone is disposed in front of the speaker unit, and said second microphone is disposed behind the speaker unit.

3. The audio reproducing apparatus as defined in Claim 1 wherein said variable gain circuit is automatically controlled.

4. The audio reproducing apparatus as defined in Claim 1 wherein said ac/dc converter is a rectifier.

5. The audio reproducing apparatus as defined in Claim 1 wherein said audio reproducing apparatus is utilized in transportation means.

FIG. 1

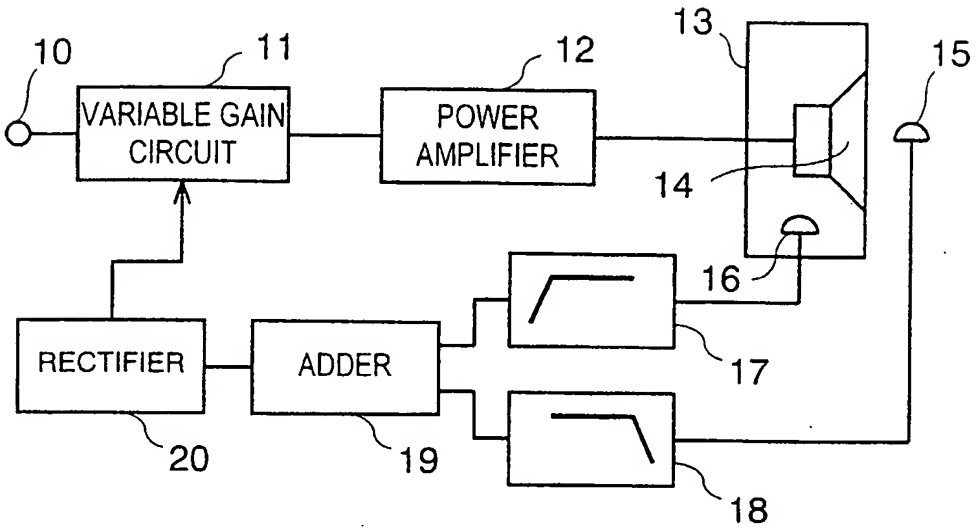
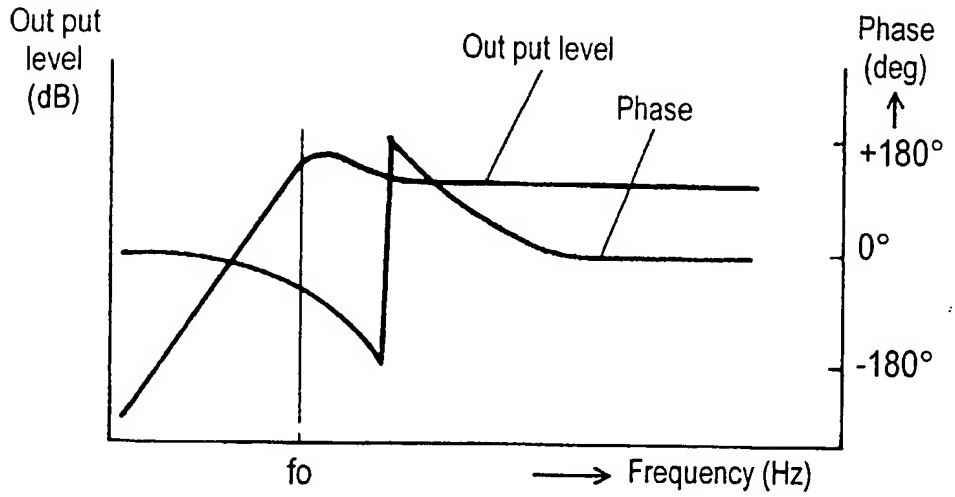

10
11
VARIABLE GAIN CIRCUIT
12
POWER AMPLIFIER
13
14
15
16
17
18
RECTIFIER
20
ADDER
19

FIG. 2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Out put level
Phase
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(deg)
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0°
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Frequency (Hz)

FIG. 3

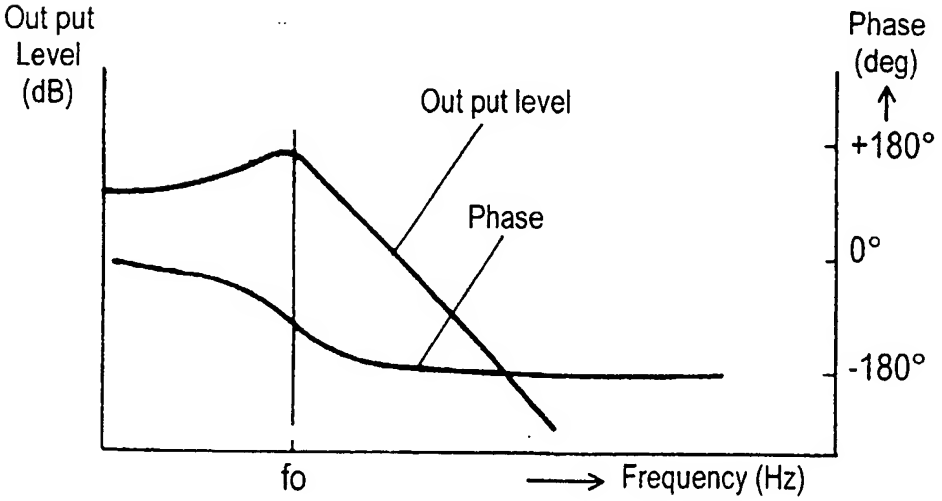
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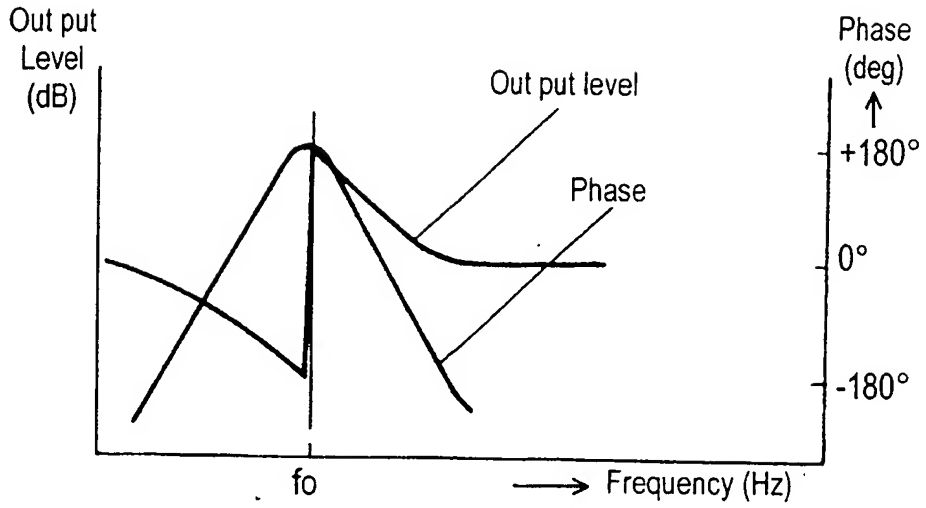
FIG. 4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Frequency (Hz)

FIG. 5

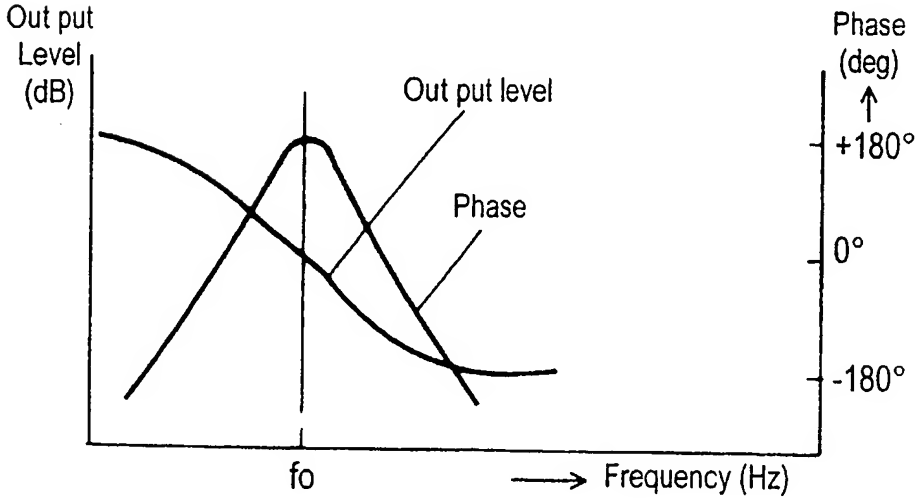
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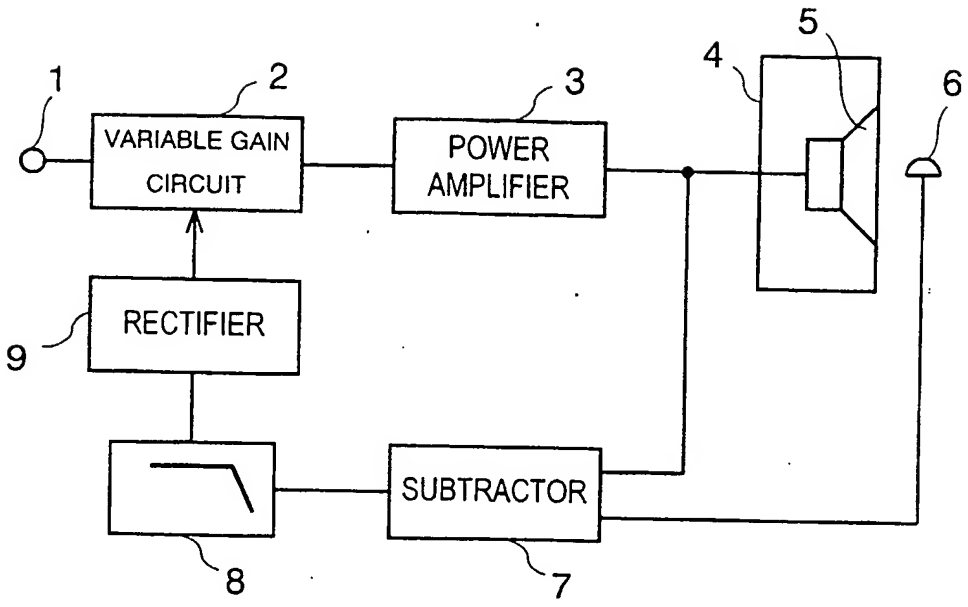
FIG. 6


1
2
VARIABLE GAIN CIRCUIT
3
POWER AMPLIFIER
4
5
6
9
RECTIFIER
8
SUBTRACTOR
7

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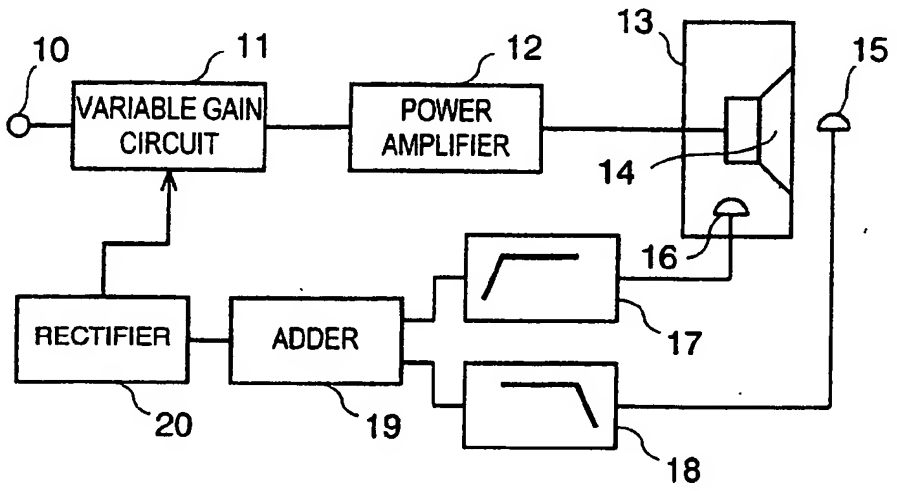

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EUROPEAN SEARCH REPORT

Application Number
EP 99 30 2765

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	PATENT ABSTRACTS OF JAPAN vol. 1998, no. 06, 30 April 1998 (1998-04-30) -& JP 10 032895 A (MATSUSHITA ELECTRIC IND CO LTD), 3 February 1998 (1998-02-03) * abstract *	1-5	H04R3/00
L	-& US 6 122 385 A (ISHIHARA SUMIO ET AL) 19 September 2000 (2000-09-19) * claims 1-3; figures 1-5 * * column 3, line 41 - column 6, line 64 *	1-5	
A	PATENT ABSTRACTS OF JAPAN vol. 014, no. 062 (E-0883), 5 February 1990 (1990-02-05) -& JP 01 282996 A (CITIZEN WATCH CO LTD), 14 November 1989 (1989-11-14) * abstract *	1-5	
A	DE 27 17 069 A (OSTERTAG ULRICH DR) 26 October 1978 (1978-10-26) * page 6, paragraph 2 - page 13, paragraph 1 * * figure 2 *	1-5	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

H04R
H03G

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	13 September 2004	Meiser, J

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